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# Explosives Research and Development Establishment

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## Technical Note No. 130

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A Mechanical Device for the Measurement  
of Blade-to-Wall Clearances in Enclosed  
Vertical Mixing Machines.

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R. Durrant

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August 1974

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EXPLOSIVES RESEARCH AND DEVELOPMENT ESTABLISHMENT

Technical Note No 130

August 1974

A Mechanical Device for the Measurement  
of Blade-to-Wall Clearances  
in Enclosed Vertical Mixing Machines

by

R Durrant

SUMMARY

A description is given of the device developed for use with a 10-gallon vertical mixer of figure-of-eight design fitted with two equispeed semi-helical solid blades rotating in fixed bearings. Blade-to-wall clearances are approximately 5 mm. High spots are detected from a linear reproduction of clearances on a paper record. The device can readily be used for a wide range of blade sizes and clearances. Risk of detachment from the blade is slight and resultant damage unlikely due to lightness.

Further copies of this technical note can be obtained from Technology Reports Centre, Orpington, Kent. BR5 3RF

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## 1 INTRODUCTION

Vertical mixing machines are preferred for safe mixing of explosive compositions whenever mix viscosities are sufficiently low to permit their use, eg for the present larger scale ERDE vertical mixers the mix viscosity limits are in the range 15 to 20 kP. In comparison with horizontal mixers increased safety of operation is obtained because of the isolation of the shaft gland seals from the explosive compound. Vertical mixers have the additional advantages of easy transference of fluid materials and easy access for cleaning.

The blade-to-wall clearances in vertical mixers are chosen having regard to the need to avoid any metal-to-metal contact under load, either due to blade deflection or vessel movement, while still achieving the efficient mixing resulting from a high swept volume.

A problem arises in respect of the direct checking of clearances in a closed vacuum mixer due to the difficulty of access when the vessel is in the raised (ie operating) position. Ideally the clearances when the machine is in service are required, but no completely successful method of obtaining these has yet been developed. The nearest approach is to measure the clearances with the machine empty and then measure or estimate blade deflections or vessel movements during mixing.

The device described in this Technical Note was developed for measuring the clearances in a 10-gallon vertical mixer of figure-of-eight design fitted with two equispeed semi-helical solid blades rotating in fixed bearings. The vessel is raised and lowered hydraulically, and the blade-to-wall clearances are approximately 5 mm. The device gives a record of the clearances at one circumferential level and is able to detect localised high spots. With only slight modification to the clamping equipment it is usable on a wide range of blade sizes, and with suitable adjustment over a wide range of clearances. The risk of detachment from the blade is slight, but should this inadvertently occur damage to the blade or wall is unlikely as the device is light enough to be swept round by the blade.

## 2 PREVIOUS TECHNIQUES FOR THE MEASUREMENT OF CLEARANCES

Various techniques have been used to measure blade-to-wall clearances, but each has disadvantages which must be borne in mind in interpreting

results. The use of feeler gauges inserted through the lid of the mixing vessel gives a static measurement at one point, and presupposes sufficient room for access. Measurements taken when the pot is heated are difficult and uncomfortable to obtain. It is, of course, impossible to obtain measurements by this method when the vessel is under vacuum. A complete set of measurements takes much time and true clearances are slightly greater than those measured due to the gauge not completely conforming to the curvature of the pot.

The use of Plasticine attached to the wall, which is then partly removed by the moving blade has not proved satisfactory because (a) the Plasticine does not always shear cleanly; (b) it is often dislodged; (c) in the case of a symmetrical blade the method only gives the clearance associated with one edge; and (d) it gives measurement over only a small area of wall. Several attempts usually are necessary before any reliable results are obtained and when clearances are required with the pot heated, difficulties are even greater because of flow of the material, impaired adhesion to the wall and problems arising from air inclusions.

Another approach is to attach to the blade edge a strip of self-adhesive foam dusted with a powdered pigment such as monastral blue. This is a useful method of determining the positions at which the clearance does not exceed the foam strip thickness, but it is limited in its application by the few thicknesses (usually 3 and 6 mm) in which adhesive foam strip is available.

It is not possible to perform a complete survey rapidly with any of the foregoing methods. A capacitance measuring technique<sup>1</sup> using a small piece of thin copper sheet attached to, but insulated from, the blade edge as one plate and the vessel wall as the other has the advantage that it allows continuous measurement at several circumferential levels on the mixer blade. Essentially the changes in capacitance caused by differing distances between the vessel wall and the plate are measured, and these are directly related to the clearances. Results however can be misleading because the mean clearance over the area of the plate is obtained rather than the clearance at any one point. Consequently potentially dangerous 'high spots' are not indicated. Another disadvantage is that the readout is on a logarithmic scale, so, for example, the trace shows little difference between clearances of 8 and 12 mm, but a great difference between 4 and 8 mm. The setting-up and calibration

time for this method is considerable, and for a 10-gallon mixer, a complete set of measurements is difficult to complete in one day.

Another electronic device<sup>2</sup> records the difference in magnetic fields between the blade and a sensor on the pot wall. This has the advantage that it can be used with a mix in the pot, and it also enables continuous measurement to be made at one point. Used at the point of minimum clearance found by other methods it could be used to show differences in blade-to-wall clearances when the mixer is under load.

### 3 A MECHANICAL CLEARANCE MEASUREMENT DEVICE

#### 3.1 General Description

A new clearance measuring apparatus has been designed and constructed which is essentially a mechanical tracing device attached to the mixer blade, enabling a record of the position of the tub wall relative to the blade edge to be obtained as the blade rotates.

The sensing element of the apparatus is a wheel which traverses the tub surface and is rotated as the blade is moved. This wheel is attached to the end of a spring-loaded square bar sliding in a square channel attached to a frame which in turn is securely attached to the mixer blade. From the sensing wheel a belt drives a paper take-up spool, via bevel wheels. At the same time, the wheel carrier bar operates a pen which is displaced linearly by movement of the bar. Thus when the blades are turned both the pen and spool are operated by the same sensor, and a record of distance along the wall against blade-to-wall displacement is automatically given.

#### 3.2 Constructional Details

The construction of the device is shown in Figure 1. The frame (1) attached to the blade fitment carries a square channel (2) within which the sensing wheel carrier (3) slides. The top plate of this channel is attached by screws, and has a slot (4) for the stop peg of the sliding bar; the side of the channel has a similar slot (5) for the pen attachment.

The sensing wheel (6) is attached to the sliding bar by means of a round rod, the position of which relative to the bar can be varied to enable different ranges of clearance to be covered. It can also be rotated slightly so that the drive wheel can be kept horizontal when the complete assembly is attached to a helical blade. The sensing wheel is fitted with a



rubber tyre and has a groove for the driving belt (7). This belt is a piece of long spliced string tensioned by a spring loaded jockey (8). It drives a pulley (9) which has a 12-toothed bevel wheel attached to the lower end of its arbor. This bevel wheel meshes with a 32-toothed bevel wheel (10) driving the take-up spool (11). Paper is delivered to this from an identical spool after passing over the writing surface (12). Both spools can be removed to allow paper to be loaded. The pen is actuated by a clamp (5) attached to the sliding bar (3). This carries a cord belt which passes over two rotatable posts, and thence thrice round a pulley, the bottom end of which carries the pen arm. The record is made by a pencil lead carried in a tube, the lead being clamped by a pinch screw. This arrangement gives linear reproduction of the movement of the sliding bar, which makes for easy interpretation of the record.

The complete assembly is fitted to the mixer blade by means of an angle bracket attached to the frame by a screw passing through the hole (14) in the frame. This bracket is shaped such that the blade edge fits into a channel and is held in place by a Bowden cable connected to a right and left hand threaded tensioner, a quick release clamp, and a bracket for the other blade edge.

### 3.3 Procedure for Use

The apparatus is clamped to the blade edge by means of the Bowden cable assembly, the tensioner being adjusted so as to hold the apparatus firmly. The mixer vessel is then raised so that the wheel makes contact with the wall just inside the top edge of the vessel. The distance between the blade and tub wall at this point is measured by means of feeler gauges, Lushington hole gauges, or some other suitable method. Lushington hole gauges are normally used. A sphere is selected which just fits between the blade and tub wall and its diameter is measured with a micrometer. The paper is moved so as to give a calibration mark at this point and a slip gauge is then interposed between the tub wall and driving wheel, and a further calibration mark made.

The entire internal surface of the vessel is then dusted with talc, and the vessel raised to the mixing position. The blades are turned by hand for one complete revolution. The pot is lowered and the talc surface checked to see if the wheel has contacted for the complete revolution. If the clearance is at any point outside the setting of the device, the talc will be

unmarked at that point and it is then necessary to adjust the sensing wheel accordingly and to repeat the calibration.

The procedure is repeated at different positions along the length of the blade, and also for the other edge of the blade so as to give a complete record of blade-to-wall clearances. The device may also be used for measurement of the clearance between the blade and vessel base. In this case calibration is carried out by means of Plasticine squeezed between the blade and base, as access with feeler gauges is impossible.

### 3.4 Treatment of Results

From the records obtained a position of maximum and minimum clearance is found for each test position on each blade and each edge. For each record a plan of the mixer pot is marked to show where contact has occurred and the position of minimum clearance (Figure 2). It has been found convenient to plot the results on a histogram (Figure 3) so as to simplify comparison with previous determinations.

## 4 CONCLUSION

A device has been developed which will give a rapid and accurate survey of the clearances between the blades and vessel in an enclosed vertical mixing machine. The range of the device can be readily altered, and high spots can be easily detected as the device gives a linear reproduction of the clearances on a paper record.

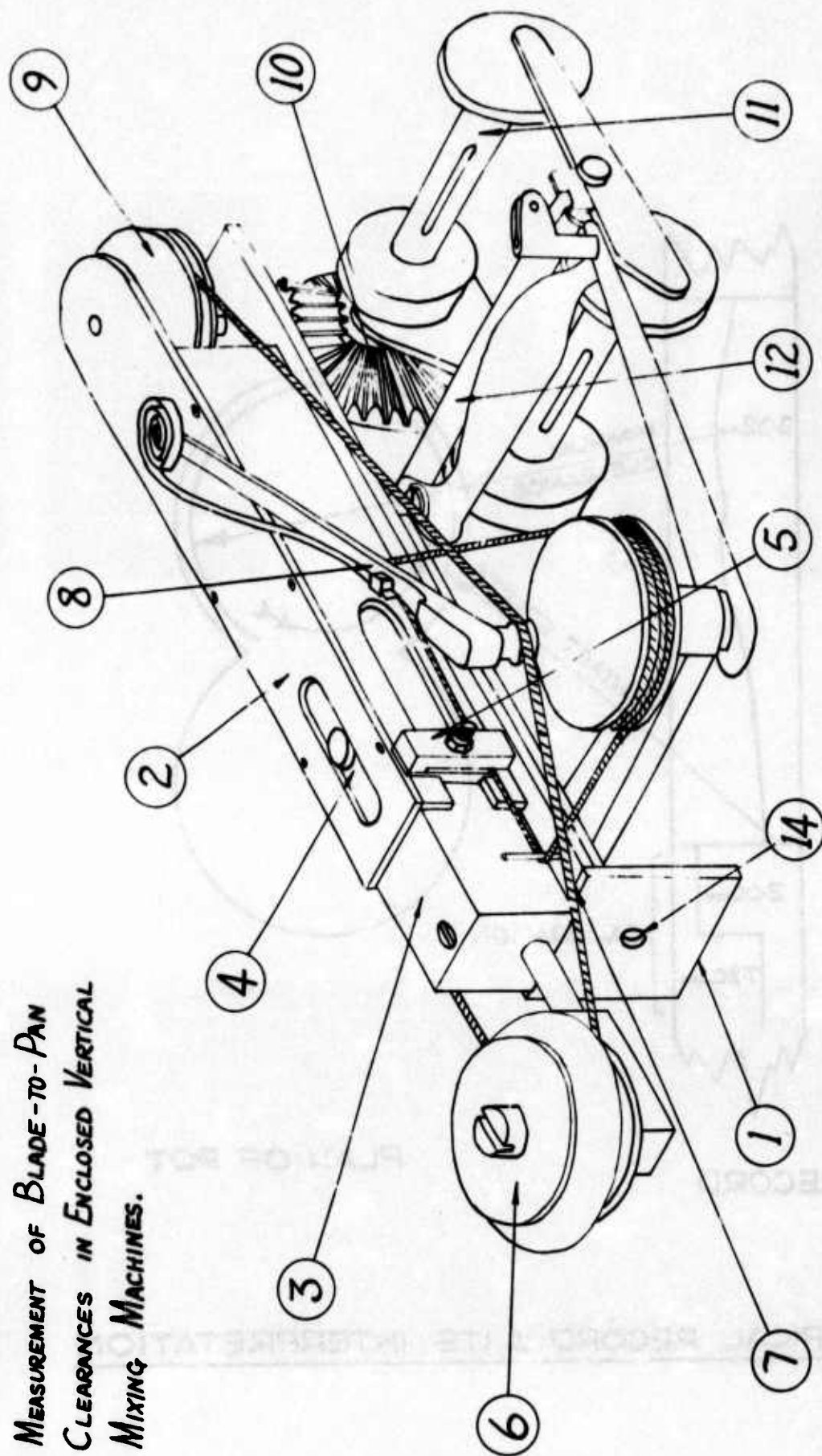
## 5 REFERENCES

- 1 Williams R G      Measurement of Stirrer-to-Wall Clearances in Unloaded Mixers by a Capacitance Proximity Gauge. ERDE Report No 11/R/67.
- 2 Cracknell R I    Electromagnetic Distance Measuring Unit. ERDE Apparatus Report, September 1968.

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The device described in this Note is covered by UK Patent Application No 14667/74.

FIG.1 A MECHANICAL DEVICE FOR THE  
MEASUREMENT OF BLADE-TO-PAN  
CLEARANCES IN ENCLOSED VERTICAL  
MIXING MACHINES.



R. Dussan  
March 1971

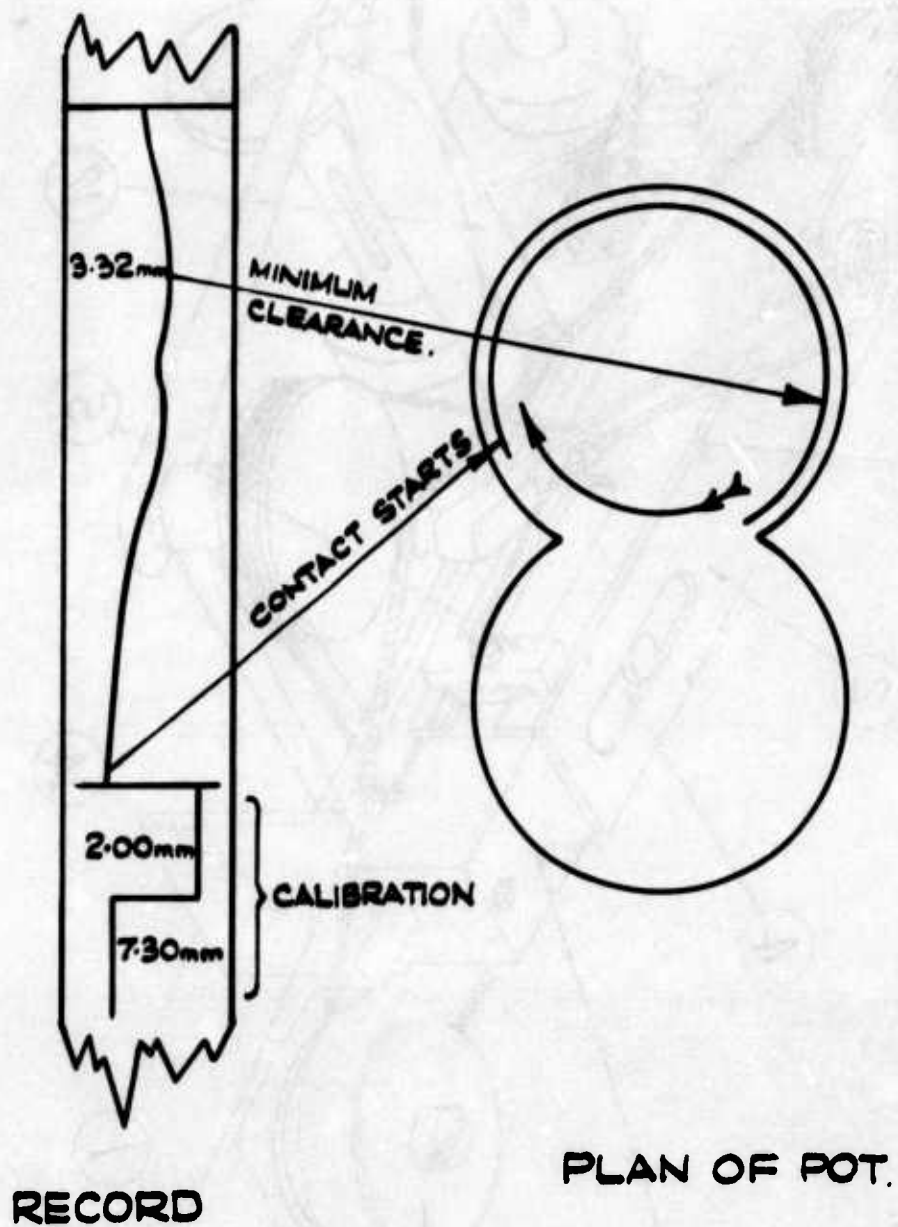


FIG 2 TYPICAL RECORD & ITS INTERPRETATION





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Descriptors (or keywords) <b>Mixing, Machinery, Clearances, Measurement, Blades</b>  <div style="text-align: right;">(TEST)</div> <div style="text-align: right;">continue on separate piece of paper if necessary</div>			
Abstract A description is given of the device developed for use with a 10-gallon vertical mixer of figure-of-eight design fitted with two equispeed semi-helical solid blades rotating in fixed bearings. Blade-to-wall clearances are approximately 5 mm. High spots are detected from a linear reproduction of clearances on a paper record. The device can readily be used for a wide range of blade sizes and clearances. Risk of detachment from the blade is slight and resultant damage unlikely due to lightness.			

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9 pp, no tabs, 3 figs

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